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**Before the**
**FEDERAL COMMUNICATIONS COMMISSION**
**Washington, D.C. 20554**

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|---|---|---|
| **In the Matter of** | ) | |
| **Amendment of Parts 2, 15, and 97** | ) | |
| **of the Commission's Rules To** | ) | **ET Docket No. 94-124** |
| **Permit Use of Radio Frequencies** | ) | **RM-8308** |
| **Above 40 GHz For New Radio** | ) | |
| **Applications** | ) | |
| | ) | |
| **International Harmonization of** | ) | |
| **Frequency Bands Above 40 GHz** | ) | |
| | ) | |
| **Petition of Sky Station** | ) | |
| **International, Inc. For Amendment** | ) | **RM-8784** |
| **of the Commission's Rules To** | ) | |
| **Establish Requirements for a Global** | ) | |
| **Stratospheric Telecommunications** | ) | |
| **Service in the 47.2-47.5 GHz and** | ) | |
| **47.9-48.2 GHz Frequency Bands** | ) | |
| | ) | |

## OPPOSITION TO PETITION FOR RECONSIDERATION

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## TABLE OF CONTENTS

**Before the**
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| | | |
|---|---|---|
| **In the Matter of** | ) | |
| | ) | |
| **Amendment of Parts 2, 15, and 97 of the Commission's Rules To Permit Use of Radio Frequencies Above 40 GHz For New Radio Applications** | ) | **ET Docket No. 94-124<br>RM-8308** |
| | ) | |
| **International Harmonization of Frequency Bands Above 40 GHz** | ) | |
| | ) | |
| **Petition of Sky Station International, Inc. For Amendment of the Commission's Rules To Establish Requirements for a Global Stratospheric Telecommunications Service in the 47.2-47.5 GHz and 47.9-48.2 GHz Frequency Bands** | ) | **RM-8784** |

**TO: The Commission**

## OPPOSITION TO PETITION FOR RECONSIDERATION

The Commission correctly decided in the Second Report and Order in the above-captioned proceeding (the "*47 GHz Order*") that global stratospheric telecommunications service ("GSTS") is the likely dominant use of the 47.2-47.5 and 47.9-48.2 GHz band (the "47 GHz band"), and that area-wide licensing and 100 MHz blocks are the appropriate licensing framework for allocating this spectrum. Four satellite companies (Hughes Communications, Inc.; GE American Communications, Inc.; TRW, Inc.; and Motorola Satellite Systems, Inc.; collectively "Petitioners") filed a Petition for Reconsideration ("Recon. Petition") on September 11, 1997 that does little more than complain that the satellite industry was not awarded yet additional spectrum. The Recon. Petition contains no credible argument as to why the Commission's findings and decisions in the *47 GHz Order* are in error or not in the public interest. Sky Station International, Inc. ("Sky Station") submits this Opposition to refute the thin allegations contained in the Recon. Petition and to urge the Commission to reject this attempt to derail or delay the successful launch of a new technology and service.

## I. INTRODUCTION AND SUMMARY

On May 2, 1997, the Commission adopted the Second Report and Order in the *Millimeter Wave Proceeding* designating the 47 GHz band for use by a variety of services, and finding that the likely dominant use of this band will be GSTS. *47 GHz Order* at ¶¶ 68-70. The Commission's decision is well reasoned, consistent with FCC policy and international consensus, and firmly based on the public record.

(1) The vast majority of commenters, including substantial public interest comments, supported designation of spectrum for GSTS.

(2) Sound and long-established spectrum management policy supports spectrum for new and innovative technologies that will compete with existing technology (and its existing substantial spectrum allocation).

(3) There is an international consensus, achieved in preparation for WRC-97, in favor of GSTS as the likely dominant use of the 47 GHz band.

(4) The tremendous spectrum efficiency of GSTS to deliver broadband services in a metropolitan environment further supports the Commission's decision.

Contrary to Petitioners' allegations, out of the more than 30 pleadings filed in response to Sky Station's position, the vast majority of comments were wholly supportive, including comments from international development and public health and safety organizations. Indeed, as the World Bank stated, "the potential that this new technology promises to bring to telecommunications, and specifically to the developing world's capacity for internal communications is most impressive. . . . The new service made possible by a GSTS-like technology can be expected to have a great impact on the level and content of communications, both within and between the developing countries . . . ."[1/] Petitioners deny this reality when they allege that there was "no support in the public record for the Commission's decision." Recon. Petition at 2. Petitioners further ignore that the only public interest comments -- as opposed to those seeking spectrum for themselves -- specifically supported designating the 47 GHz band for stratospheric telecommunications service. Moreover, all of the public interest comments predicted large-scale use of the stratospheric telecommunications service at the 47 GHz band. Basing its decision on this public record, the Commission had a reasoned basis for deciding that GSTS would be the likely dominant use of the 47 GHz band.

Petitioners also complain that the designation of 500+500 MHz paired bands will have "disastrous effects" on satellite services and that the Commission paid insufficient attention to the track record of satellite companies. These claims are without merit. First, Petitioners offer nothing but the unsupported and empty assertion that providing stratospheric service with up to 7% of the virgin V-band (1,000 MHz out of the

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[1/] Comments of The World Bank at 1.

14,000 MHz available in 36-51 GHz) would be "disastrous" to the satellite industry. More than enough spectrum is available to accommodate the reasonable needs of the satellite industry.[2] Second, it is obvious bootstrapping for Petitioners to claim that their paper systems dropped off at the FCC in the form of applications constitute any measure of real spectrum demand. Third, Petitioners' claim of a "proven track record" glosses over numerous examples where Petitioners have filed applications that have served only to tie up spectrum for years -- to the great disadvantage of their competitors and the public.

The simple fact is that Petitioners have clothed a not-surprising anticompetitive attack on the stratospheric telecommunications service as an attack on the Commission's *47 GHz Order*. Just as satellites in the 1960's represented a tremendous breakthrough to terrestrial technology, and were no doubt opposed by persons invested in existing technology, today GSTS offers a tremendous breakthrough in spectrum use that is being opposed by those invested in current technology. Petitioners are well aware of the basic metric that stratospheric systems are orders of magnitude more spectrum efficient than satellite systems, because stratospheric platforms are much closer to the surface of the earth and the platforms enjoy distinct power advantages and spectrum reuse capabilities. *See* Appendix I, "Comparative Efficiency Analysis". It is fear of this

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[2] In the entire 36-51.4 GHz band, approximately 80% of the commercially available bandwidth has already been designated or proposed for use by satellite services. *See* 47 CFR § 2.106, and *Millimeter Wave Proceeding First NPRM.* If the above-40 GHz portion of the band (i.e., 40-51.4 GHz) is considered, the picture is even more dramatic: satellite services have access to approximately 96% of the commercially available bands in that portion of the spectrum.

spectrum efficiency advantage of stratospheric systems which transparently drives Petitioners to make their unfounded arguments. The Commission should reject this effort and move promptly to the licensing of this exciting new service.

## II. THE RECORD PROVIDES AMPLE EVIDENCE TO SUPPORT THE COMMISSION'S FINDING THAT GSTS WILL LIKELY BE THE DOMINANT USE OF THE 47 GHZ BAND.

In the *47 GHz Order*, the Commission concluded that the likely dominant use of the 47 GHz band will be global stratospheric service. *47 GHz Order* at ¶¶ 68-70. The Commission based this determination on ample evidence in the record demonstrating that GSTS offers concrete advantages that will lead to the likely success of this technology and benefit the public it will serve. Those advantages include (i) low-cost global telecommunications services resulting from GSTS' efficient use of the spectrum; (ii) high bandwidth for fixed services; and (iii) smaller initial investment and modular technology that reduces entry barriers.

<u>Low cost and high efficiency.</u> A critical advantage that stratospheric telecommunications service offers is the low-cost of providing voice and data bandwidth to people all over the world. This low-cost advantage stems in part from the tremendous efficiency of the stratospheric system. As explained in detail in Appendix I, the efficiency of stratospheric platforms results from the relatively close proximity of the platforms to the earth. Even assuming that a satellite system had the same antenna gain, spectrum reuse, and modulation efficiency as a stratospheric system, the spectrum utilization efficiency ("SUE") of a stratospheric station is thousands of times greater than a satellite system because the platform is so much closer to the earth. *See* Appendix 1.

The spectrum utilization efficiency of stratospheric platforms is increased substantially when power and spectrum reuse advantages are taken into account. *See id.*

The record before the Commission offers strong support for a service that can offer low-cost communications in the U.S. and around the world. For instance, the African Development Bank stated that "[t]he high cost and unavailability of satellite communications systems limit the way we do our work."[3/] The African Development Bank endorsed stratospheric service because it offers cheaper global communications.[4/] Similarly, The World Bank stated that the cost and periodic unavailability of satellites hinder development efforts, and that low-cost stratospheric services would benefit their mission.[5/] Advanced Telecommunications Technologies discussed the cost advantage stratospheric service enjoys (such as savings in launch and maintenance costs), concluding that this low-cost service will "revolutionize telecommunications."[6/] Numerous international public health and safety organizations supported GSTS because it offers affordable communications that enables public service organizations to fulfill their missions around the world both more effectively and more economically.[7/]

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3/ Comments of African Development Bank at 1.

4/ *Id.* at 2.

5/ Comments of The World Bank at 1.

6/ Comments of Advanced Telecommunications Technologies, Inc. at 1.

7/ *See, e.g.,* Comments of The National Institute for Urban Search and Rescue at 1; Comments of Mercy Medical Airlift at 1-2; Comments of Olympic Family Clinic at 2; Comments of Center for Public Service Communications at 1.

A number of parties also addressed the versatility of the stratospheric platforms and its beneficial use for newsgathering, search and rescue missions, weather predictions, ozone monitoring, and other activities.[8] These benefits buttress the Commission's finding that the public interest will be served by designating spectrum for GSTS.

High bandwidth. One of the most exciting aspects of stratospheric service is its ability to provide high density broadband service that could be used for voice, data, or Internet access. GSTS has this enhanced capability because of the high power and close proximity of the stratospheric platform to the earth and the fact that the platforms are virtually stationary. One of the world's leading manufacturers of high-speed data and Internet access equipment, U.S. Robotics, urged the Commission to designate the 47 GHz band for stratospheric services, "thereby encouraging the development of new technologies to realize the potential such broadband communications will create."[9] Other commenters also recognized that this high bandwidth capability represents a tremendous benefit to the public.[10]

Modular system with low investment. As Sky Station explained in its comments, a single stratospheric platform can begin offering service to a metropolitan

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[8] *See, e.g.*, Comments of United States Information Agency at 1; Comments of Climate Institute at 1; Comments of UCLA Professor Y. Rahamat-Samii at 1.

[9] Comments of U.S. Robotics at 3.

[10] *See, e.g.*, Comments of African Development Bank at 1; Comments of Advanced Telecommunications Technologies, Inc. at 1; Comments of UCLA Professor Y. Rahamat-Samii at 1.

area almost immediately after it is launched.[11/] With stratospheric service, there is no need to launch three, or thirty, or three hundred satellites before service can be initiated. This feature contributes to the low cost of GSTS, and also explains how the service can provide immediate benefits to developing countries. However, the service is also scaleable: as new stratospheric platforms are put into place they can be readily integrated into the existing service and the reach of the service will thus be expanded. This modular approach to deploying advanced telecommunications services holds much appeal to developing nations which are searching for "[a]n affordable broadband national . . . network [that] would enable us to increase the impact we have in our development projects."[12/]

* * * *

Petitioners' claim that the Commission's decision was not grounded in the record and not adequately explained is refuted by the evidence outlined above.[13/] This claim also fails because it distorts the role of the expert agency. Courts do not require that <u>all</u> policy alternatives be considered by an agency,[14/] though in this case the Commission took care

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11/ Sky Station Request and Petition at 3-8; *see also* Sky Station Application at 15-23.

12/ Comments of African Development Bank at 1.

13/ Petitioners seek to draw a parallel with the recent decision in *Illinois Public Telecommunications Assoc. v. FCC,* 117 F.3d 555 (1997). *See* Recon. Petition at 5. No such analogy can be drawn. In that case, the court found the record "replete with evidence" contrary to the FCC's decision and that the Commission failed to consider. By contrast, the record here is replete with evidence *supporting* the Commission's decision; in fact, a contrary decision would be subject to close judicial scrutiny.

14/ *See, e.g., Motor Vehicle Mfrs. Ass'n v. State Farm Mut. Auto. Ins. Co.,* 463 U.S. 29, 44, 51 (1983).

to review all of the arguments of the satellite industry. *See 47 GHz Order* at ¶¶ 31-42. Instead, as the Supreme Court has repeatedly recognized, agencies must be allowed to exercise judgment, and courts demand only that the agency explain the evidence and offer a rational connection between the facts in the record and its decision.[15] The deference given to agencies in assessing their exercise of judgment is greater when predictions are involved. As the Supreme Court held in sustaining an FCC decision: "[C]omplete factual support in the record for the Commission's judgment or prediction is not possible or required; 'a forecast of the direction in which future public interest lies necessarily involves deductions based on the expert knowledge of the agency.'"[16]

## III. PETITIONERS' ARGUMENT THAT THE SATELLITE INDUSTRY HAS A DEMONSTRATED INTEREST IN THE 47 GHZ BAND AND THAT THE SPECTRUM SHOULD BE RESERVED FOR THEM EXCLUSIVELY IS MISLEADING AND CONTRARY TO SOUND SPECTRUM MANAGEMENT.

Petitioners make much of the fact that several satellite applications have been filed recently, citing "this abundant evidence of heavy satellite interest in the 47 GHz band." Recon. Petition at 7. But the conclusion does not follow from the argument. Numerous satellite applications have been filed for a simple reason: the Commission opened a filing window. If the Commission were to open a filing window for

[15] *Id.* at 43.

[16] *FCC v. National Citizens Comm. for Broadcasting,* 436 U.S. 775, 813-814 (1978) (quoting *FPC v. Transcontinental Gas Pipe Line Corp.*, 365 U.S. 1, 29 (1961)).

stratospheric service, Sky Station expects that the Commission would receive a similar showing of interest.

More fundamentally, however, Petitioners' claim that because the satellite industry has an interest in the spectrum it should be reserved for satellite service, is contrary to the Commission's long-standing spectrum management policy and the public interest.

*First,* given the large amount of spectrum devoted to satellite services, the Commission acted prudently as a matter of spectrum management policy to set aside a small amount of new spectrum for a new technology, namely stratospheric telecommunications service. The Commission has long recognized that it is wise to set aside a small amount of spectrum for new and innovative uses as a means of encouraging competition and new service development.[17/] That policy was particularly apt here because the Commission realized that GSTS, with its high angle of elevation, was a

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[17/] *See, e.g., Fleet Call, Inc. Request For Waiver and Other Relief To Permit Creation of Enhanced Specialized Mobile Radio Systems in Six Markets*, 6 FCC Rcd 1533 at ¶ 13 (1991) ("Intelligent spectrum management requires that providers of land mobile radio service operate as efficiently as possible, and we have consistently encouraged both private and common carriers to develop new technologies to meet increasing demand."); see *also, First Report and Order and Second Notice of Inquiry*, Docket No. 18262, 19 RR 2d 1663, 1665-66 (1970); *Commissioner Ness, "Spectrum Management Principles for the 21st Century,"* 1996 FCC Lexis 3268 (June 10, 1996) ("[T]he public interest is best served if government has the power to review usage and to reallocate spectrum, if necessary, to increase efficiency or introduce new, innovative services. One cannot leave that task entirely to the marketplace.").

perfect fit with the propagation characteristics of millimeter waves and thus could make an efficient and effective use of spectrum that has inherent limitations.[18]

*Second,* Petitioners ask the Commission to reverse its 47 GHz decision on the basis of applications Petitioners have filed for systems to be operated in the 36-51 GHz band. But Petitioners lack credibility when they assert without factual basis that the designation of 500+500 MHz of spectrum for GSTS out of the 14,000 MHz of spectrum between 36-51.4 GHz would have a "disastrous effect on the satellite industry." Recon. Petition at 6.

Consider the current allocation of spectrum to satellite services. The satellite industry occupies over 1000 MHz of spectrum at over 20 orbital locations in the C-band; over 1500 MHz of spectrum at over 20 orbital locations in the Ku-band; and over 2000 MHz of spectrum at GEO, MEO and LEO orbits in the Ka-band. Combined investment in the orbiting systems at C-band and Ku-band exceeds $5 billion. It is not believable that designating 1000 MHz out of 14,000 MHz in the new V-band -- about 7% of the spectrum -- would have a "disastrous" or even noticeable effect on the satellite industry. That amount of spectrum is insignificant compared with the industry's huge frequency allocations in the C, Ku and Ka-bands, plus its 80% or more use of the virgin V-band.

*Third,* Petitioners would have the Commission ignore the public record compiled in this proceeding as well as the global consensus in favor of dominant

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[18] *See generally* OET Bulletin No. 70, *Millimeter Wave Propagation: Spectrum Management Implications,* 1997 FCC Lexis 4146 (Aug. 5, 1997).

stratospheric use of the 47 GHz band. This international consensus on GSTS has been manifest in an unusual show of support for a new technology. The current U.S. proposal to WRC-97, which is also an Inter-American Telecommunications Commission (CITEL) Joint Proposal adopted by nine other countries in the Americas, including Canada and Mexico, provides for the "designation of the bands 47.2-47.5 and 47.9-48.2 GHz within the fixed service so that a common band is available for [stratospheric/high altitude] systems on a global basis."[19/] The world's major regional telecommunications organizations (CEPT in Europe, CITEL in the Western Hemisphere, and APT in the Asian Pacific Region) also have notified the International Telecommunications Union of their support for global stratospheric service in the 47 GHz band.[20/] This international consensus, affirmed by the Commission in the *47 GHz Order*, should not be disturbed absent a strong showing. Otherwise, the ability of the U.S. to accomplish its goals at the upcoming World Radio Conference (WRC-97) would be put in jeopardy. As Commissioner Ness stated earlier this year: "Spectrum policy has an international dimension. Radio waves don't stop at national boundaries. Some spectrum decisions grow out of -- or are limited by -- worldwide and regional negotiations."[21/]

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19/ CITEL Joint Proposal for the Work of the Conference, WRC-97, Proposal for Agenda 1.9.6, PCC.III/doc875/97REV.3 (25 September 1997).

20/ *Id.* (10 countries have adopted CITEL proposal); European Common Proposals for the Work of the Conference, Agenda Item 1.9.6, High Altitude Relay Platforms (Sky Station), CEPT/ERC/CPG(96)54 Rev.2 - Part 5C at 23 (more than 30 countries have adopted CEPT proposal); Asia-Pacific Telecommunity Common Proposals for the Work of the Conference, Part 14, FS Bands Above 30 GHz, Document APT 23 (1 August 1997) (18 countries have adopted APT proposal).

21/ "Remarks of Commissioner Ness before CTIA's Wireless '97," 1997 FCC LEXIS 1231 (March 4, 1997).

*Fourth,* the Commission should cast a skeptical eye at the recent flurry of satellite industry interest in the 47 GHz band. The track record shows that some satellite companies submit paper applications to the FCC that unproductively tie up spectrum for years.[22/]

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22/ Consider the Petitioners' history of not implementing systems that they propose:

1. In 1983 Hughes filed with the FCC an application for a geostationary Ka-band satellite communications system. It was purported to be an alternative to the Ka-band ACTS system then under construction by NASA. This system proposed by Hughes was licensed by the FCC, but never built, launched or operated by Hughes. Indeed today, a decade after Hughes said they were going to operate Ka-band satellite systems, the system remains on the ground.

2. In 1990 TRW filed with the FCC an application for a LEO L/S-band system called Odyssey. The Commission licensed this system in 1995. While other LEO L/S-band licensees moved promptly to close their system financing, and even commence launching their satellites, TRW has yet to launch a single satellite licensed to it by the FCC. Indeed, TRW has yet to even announce the completion of even half the financing it needs for the system, more than a year after receiving its FCC license.

3. In 1995, at the request of GE American Communications, the FCC granted its request for a license to construct, launch and operate the previously licensed StarSys low earth orbit satellite system. GE American had waxed eloquently about its plans to operate a worldwide satellite system in the scarce frequency bands. Just over a year later, GE returned the license to the FCC saying it had "changed its business plans."

4. Motorola Satellite Communications is a new unit of Motorola, but its parent, Motorola Inc., has failed to implement various systems that it has proposed to the FCC. In 1984 Motorola announced with much fanfare its "Coverage Plus" system to cover the entire continental United States with a ground based mobile radio system using SMR frequencies. This service was never more than partially rolled out before it was sold to Qualcomm and subsequently abandoned. As for Motorola Satellite Communications, the fact is that it has not yet implemented any system that it has proposed -- not Iridium (although 10% of the planned satellites have been launched), not Celestri and certainly not MStar.

In light of reviewing this evidence of satellite companies having failed to implement the paper systems that they propose, the Commission is well-founded in

(continued...)

*Finally,* the Recon. Petition is misdirected because the main target of Petitioners appears to be the service rules for the 47 GHz band, which have yet to be written. *See, e.g.*, Recon. Petition at 4. The *47 GHz Order* expressly states that the service rules will be considered in a separate proceeding and that the Commission will craft rules permitting new and innovative uses and technologies to take advantage of this band, consistent with what the Commission expects will likely be the dominant use of this spectrum. *47 GHz Order* at ¶¶ 68-70. Petitioners essentially complain that those service rules foreclose their use of this band, but that claim is at least premature. Consequently, the Commission could simply reject the Recon. Petition lodged against the *47 GHz Order* on the ground that Petitioners' arguments should be considered, if at all, in the forthcoming service rules proceeding.

## IV. THE LICENSING FRAMEWORK ADOPTED IN THE 47 GHZ ORDER PROMOTES EFFICIENCY AND IS IN THE PUBLIC INTEREST.

Petitioners contend in a perfunctory fashion that the Commission's licensing framework is untenable. Recon. Petition at 10. This claim can be readily dismissed.

The Commission adopted an area-wide licensing plan that was supported by or not opposed by the majority of commenters.[23] The Commission's proposal for an

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[22](...continued)
setting aside a small portion of the V-band for a revolutionary technology rather than speculative satellite proposals.

[23] *See, e.g.*, HCP Reply Comments at 2; TIA Reply Comments at 9; Comments of HP at 2; Comments of Pacific Bell at 2-3; *see also 47 GHz Order* at ¶ 75.

area-wide licensing plan originated in the Commission's *First NPRM* in the *Millimeter Wave Proceeding*, and has found general support. The reason is that area-wide licensing in the context of wireless services gives licensees the flexibility they need to operate a system, encourages innovation, and is easier to administer by the Commission.[24] Over the past decade or more the Commission has gained rich experience in defining licensing areas for various wireless services (e.g., cellular, PCS, SMR, LMDS), and its considered judgment on the appropriate licensing area is entitled to substantial deference.

Petitioners also challenge the Commission's decision to divide the spectrum in the 47 GHz band into paired 100 MHz license blocks. The Commission reached this decision after reviewing all comments, *see 47 GHz Order* at ¶¶ 81-83, and concluding that this band segmentation plan best promotes the most efficient and effective use of the band. Dividing the spectrum into paired 100 MHz blocks allows for intensive use of the spectrum and enables a larger number of licensees to use the spectrum and to bring their technology to the public.

One final claim needs to be addressed -- that Sky Station said it could operate with as little as 10+10 MHz of spectrum. What Sky Station said was that the Commission could avoid mutual exclusivity by assigning each qualified stratospheric applicant with 10+10 MHz of spectrum; in that event, Sky Station anticipated that each licensee could negotiate with others to combine their spectrum allotments into a viable system.[25] However, the Commission decided instead to deal with mutual exclusivity by

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[24] *See* Comments of HP at 2; *47 GHz Order* at ¶ 80.

[25] *See, e.g.*, Sky Station Reply Comments at 8.

structured auctions of bandwidths suitable for accommodating the needs of their likely dominant use. Sky Station fully supports the Commission's decision. To set the record straight on the spectrum needs of its service, Sky Station requires a minimum of 100 MHz in each direction and expects to occupy even more spectrum as the service proves itself in practice.

## V. PETITIONERS' COMPLAINT OF INADEQUATE NOTICE IS WITHOUT MERIT.

Petitioners complain that they lacked adequate notice with respect to the Commission's decision, adopted on May 2, 1997, apparently because Sky Station filed late comments on Christmas Eve, 1996. *See* Recon. Petition at 11. This challenge is without merit.

- The Commission's authority to accept late-filed comments is well established.[26]

- The Commission has held time and again, in the context of the PCS rulemaking as well as in other contexts, that notice is proper even if the final rule is not identical to the proposed rule, as long as it is a logical outgrowth of the proceeding.[27]

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[26] *See* 47 C.F.R. § 1.415(d); *see also, e.g., Rulemaking To Amend Parts 1, 2, 21, and 25 Of the Commission's Rules to Redesignate The 27.5-29.5 GHz Frequency Band; To Reallocate the 29.5-30.0 GHz Frequency Band; To Establish Rules and Policies for Local Multipoint Distribution Service And for Fixed Satellite Services; Petitions for Reconsideration of the Denial of Applications for Waiver of the Commission's Common Carrier Point-to-Point Microwave Radio Service Rules; Suite 12 Group Petition for Pioneer Preference*, 6 Comm. Reg. (P & F) 1291 (1997).

[27] *See Amendment of Parts 2, 22, and 25 of the Commission's Rules to Allocate Spectrum for, and to Establish Other Rules and Policies Pertaining to the Use of Radio Frequencies in a Mobile Satellite Service for the Provision of Various Common Carrier*

(continued...)

The courts have endorsed this view as well.[28] (Otherwise, a rulemaking would be a sterile, inflexible, take-it-or-leave-it process.) The Commission's decision in the *47 GHz Order* on dominant use of the band, area-wide licensing, and size of license blocks all stem from the *First NPRM* and clearly meet this standard.

- Petitioners make no showing of prejudice. Though Sky Station filed its comments on December 24, the Commission did not adopt a decision until May 2. In the PCS proceeding, for example, Motorola submitted late-filed comments only weeks before adoption of the allocation order and yet those late comments featured prominently in the Commission's final decisions.[29] In this proceeding, all parties had ample time to review the comments and respond.[30]

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[27](...continued)
*Services,* 4 FCC Rcd. 6016, 6021-22 (1993) ("*PCS Allocation Order*"); *see also Amendment of Part 73 of the Commission's Rules to Permit Short-Spaced FM Station Assignments by Using Directional Antennas,* 1989 FCC Lexis 993, at *6-7 (1989).

[28] *See, e.g., Small Refiner Lead Phase-Down Task Force v. EPA*, 705 F.2d 500, 546 (D.C. Cir. 1983) (APA requires that final rule must be "logical outgrowth" of notice); *Natural Resources Defense Council, Inc. v. Thomas*, 838 F.2d 1224, 1242 (D.C. Cir. 1988) (same); *Logansport Broadcasting Corp. v. United States*, 210 F.2d 24, 28 (D.C. Cir. 1954) (notice is sufficient if it includes "a description" of relevant issues).

[29] *See, e.g., PCS Allocation Order* at ¶ 30-42.

[30] *See WATS-Related and Other Amendments of Part 69 of the Commission's Rules,* 59 Rad. Reg. 2d (P&F) 1418 (The Commission rejected late-filed comments because they were filed one day before release of the Sunshine Agenda Notice announcing consideration of the order, such that the Commission was "therefore unable to receive and consider responses to it from other interested parties.") This case certainly suggests that if over four months remained to receive responsive comments, there would have been no notice problem and the comments would have been accepted.

## CONCLUSION

For the reasons stated above, the Petition for Reconsideration of the Commission's *47 GHz Order* should be rejected.

Respectfully submitted,

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October 17, 1997

**APPENDIX**
**Comparative Efficiency Analysis Among A Stratospheric System, M-Star, and Expressway**

By Dr. Yee Chun Lee

The information provided in the M-Star application and the Expressway application demonstrate that M-Star is 32,400 less spectrally efficient and Expressway is 3,615 less spectrally efficient than a conservatively designed stratospheric system. Moreover, Expressway must use aggressive assumptions to obtain this ratio of efficiency including extremely costly and heavy satellites, very large high gain antennas, and a comparatively low availability of service. The following analysis provides the basis for the ratios and explains why M-Star, like all satellite systems, is necessarily far less spectrally efficient than stratospheric systems.

## I. Introduction and Summary

To compare systems, one needs a meaningful measure of spectral efficiency. A system that provides a large amount of data may be very inefficient if it requires excessive bandwidth or has a large geographic footprint that precludes other services from providing additional data. As a result, efficiency should be determined as a data rate per unit time, per unit bandwidth, and per unit of coverage area. The following formula is commonly used and accounts for the above concerns:

$$\text{Efficiency} = M/B{\cdot}A{\cdot}T$$

where M is the total number of bits of data provided by a service in time T, using bandwidth B, and having a coverage area A. It is common to report M/T as a number of channels that provide 64,000 bits of data per second.

To get a feel for the relative efficiencies of stratospheric and satellite systems, we can compare the efficiency of two proposals for each service. In particular, one can use the above formula to compare the efficiency of the Sky Station, Expressway and M-Star proposals:

A. M-Star

Based on the information in M-Star's application, one can deduce that a single satellite in the system could provide up to 109,440 channels, each providing 64,000 bits per second (M/T in the formula). It has a coverage area of 12,566,370 square kilometers (A in the formula) and requires 3000 MHz of spectrum for both uplink and downlink (B in the formula). Simply using the formula above, the efficiency is computed to be $2.90{\cdot}10^{-6}$ channels/MHz/(km)$^2$.

B. Expressway

Based on the information in Expressway's application, a single satellite could provide up to 960,000 channels, each providing 64 thousand bits per second (M/T in the formula). It has a footprint of roughly 12,000,000 square kilometers (A in the formula) and requires 3000 MHz of spectrum for both uplink and downlink (B in the formula). Simply using the formula above, the efficiency is computed to be .0000267.

C. Sky Station

Using the conservative assumptions outlined below, a single Sky Station platform can provide 181,600 channels, each providing 64,000 bits per second. It has a much smaller coverage area of 19,114 square kilometers and requires only 100 MHz of spectrum for uplink and downlink. As a result, Sky Station's proposed service has an efficiency of .094 channels/MHz/(km)$^2$.

The efficiency of the proposed Sky Station system is thus 32,400 times greater than the M-Star system.

An examination of individual systems as above does not indicate the full extent of the benefits of stratospheric service over satellite services. This is because individual systems use different antennas. Satellite systems may try to compensate for the vast efficiency differential by using more expensive higher-gain antennas that will increase the cost of the service to the public. Power considerations, however, prevent a meaningful reduction of the gap, because, all other variables being held constant, efficiency is proportional to power, and the power achievable in orbit is limited.

A simple model using a single model antenna can be used to understand the effect of power, bandwidth and distance. From Pritchard's formula, it is known that efficiency is proportional to the power (P), divided by the product of the coverage area (A) and bandwidth used (B):

$$\text{Efficiency} \propto P/A \cdot B$$

As discussed below, the radius of the coverage area varies as the distance of the antenna from the earth. This means that coverage area varies as the square of the distance and the efficiency drops with the square of the distance. Given that stratospheric systems are located at 21 kilometers and satellites orbit at approximately 1300 kilometers (using M-Star as a guide), the significantly lower altitude of stratospheric systems increases the efficiency by a factor of more than 3800. Stratospheric systems also have more available transmitter power. For example, M-Star has only 1.5 kW of available power, whereas a stratospheric system has 20 kW. If one then considers the lower bandwidth requirement as above, the stratospheric system would be 1.56 million times more efficient than a satellite system using the same antenna.

## II. Detailed Analysis

### A. Spectral Utilization Efficiency Formula.

A common formula for measuring the efficiency of spectrum use by wireless systems is known as the Spectrum Utilization Efficiency formula (National Spectrum Management Handbook, Chapter 6). Spectrum utilization factor ("SUF") is defined to be the product of the bandwidth B, the area A, and the time T denied to other potential users: SUF = B x A x T. The Spectrum Utilization Efficiency ("SUE") of a wireless communications system can be expressed by = M / SUF, where M is the total amount of information bits delivered during the time T other potential users were denied access of the specific spectrum.

The SUE takes into account the area of the entire area of the footprint of the station's designed coverage area. For example, the footprint for an Expressway satellite in V-band is about 4,000 kilometers by 3,000 kilometers, and Expressway is requesting a frequency allocation of 3 GHz in each direction for the entire footprint of the satellite system. Even though the Expressway system could only cover a small fraction of the footprint area due to the lack of power and the great distance it has to cover, its spectral efficiency under the SUE formula, takes into account the entire footprint area.

### B. Spectrum Utilization Efficiency Applied to the Stratospheric, M-Star and Expressway

The following demonstrates that based upon the Spectral Utilization Efficiency formula the stratospheric system is 32,400 times more efficient than M-Star, and 3,615 times more efficient than Expressway.

#### (1) Stratospheric System's SUE (.094).

A conservatively designed stratospheric system using one platform that is 140 meters in length and 50 meters in diameter can generate enough power to dedicate 20 kilowatts of DC power to its payload. Such a platform located at an altitude of 21 kilometers with an allocation of 100 MHz of spectrum in each direction can generate a frequency reuse pattern of 1:9 within a 154 kilometer diameter footprint. Such a system would reuse the allotted frequency 77 times (77x9=693). Because of the 1:9 frequency pattern, each spot beam has a frequency of 11.1 MHz (100/9). With a coding efficiency of 1.2bits/s/Hz (i.e., 1.2 bits per second for each allocated Hz) and a signaling and ATM header overhead of ~ 20%, the stratospheric system can achieve a data efficiency of one data-bit per Hz. Thus, the capacity per spot beam is 11 Mbps, and the total user capacity per platform is (11x9x77)=7.6 Gbps, which translates into 119,100x(64k) channels. If gateway channels (4.0Gbps) are included in the same manner that Expressway 's gateway channels were included above, the total capacity is 11.6 Gbps per station.

Since the footprint of the stratospheric system has a radius of 78km, or 19114 square km, it has a spectral efficiency SUE is 0.094 channels/MHz/(km)$^2$.

(2) M-Star's SUE (.0000029)

Motorola, in its M-Star application, states that it "will provide 2.048 Mbps (E-1) to and from multiple remote sites that can be backhauled to a hub at 51.84 Mbps (OC-1)". [Before the FCC, Application of Motorola Satellite Systems, Inc. for Authority to Construct, Launch and Operate the M-Star System, September 4, 1996, Page 14]. It further states that "Each cell-to-MTSO (Mobile Telephone Switching Offices) WAG (Wireless Access Group) is formed from a 5-channel, 18Mhz/channel FDMA plan; each channel, in turn, supports a 5-timeslot TDMA format. Hence, each of the channel-slot elements can support a 2.048 Mbps data rate. Twenty-five cell sites of 2.048 Mbps can be supported by a cell-to-MTSO WAG yielding a 51.84 Mbps overall rate."[Page 47.] Thus, each MTSO WAG can support 25 cell sites of E-1, or 800 (64k) channels.

Furthermore, "The WAG multiplexing permits a group of 25 cell sites to be associated with one MTSO during a frame time. Up to ten such frames can be grouped if needed to associate as many as 250 (25x10) cell sites with an MTSO." [Page 48.] Later, it says, "A single space vehicle will support as many as 1,800 cell sites, each operating at E-1 rates with as many as 250 cell sites in a single beam coverage area." [Page 50.] And "Based on conservative de-rating factors, the system can support greater than 43,000 simultaneous equivalent E-1 channels on the user service links over land mass. Additionally, the constellation can support over 1,500 additional equivalent OC-1 channels globally." [Page 50.]

The M-Star system has a total of 12x6 = 72 satellites [Page 30], each satellite includes 72 WAG transponders, 32 OC-1 point-to-point transponders [Page 43], and the number of communication beams per satellite is 32 [Page 34.].

A single M-Star satellite has a footprint of 2,000 km radius. [Page 37]. This gives a total coverage area of 12,566,370 square km. Each M-Star satellite has a capacity of 1,800 E-1 and from 32 to 64 OC-1's, for a total of up to 7,004 Mbps (1,800x2.048+64x51.84 = 7,004). This is equivalent to 109,440 (64k) channels. Also, it assume a 3000 MHz allocation each way [Page 34.] "The system design requires 3 GHz for uplink communications at 47.2 to 50.2 GHz and 3 GHz for downlink communications at 37.5 GHz to 40.5 GHz."[34]. Hence the SUE for M-Star is 109,440/3,000/12,566,370 or $2.90 \times 10^{-6}$ channels/MHz/(km)$^2$.

Based on the above conclusions, the relative efficiency between the conservatively designed stratospheric system and the M-Star system is $\gamma = 0.094/2.90 \times 10^{-6} = 32{,}400$. Therefore, the stratospheric system is 32,400 times more efficient than the M-Star system under the SUE formulation.

(3) Expressway 's SUE (.0000267).

Hughes Communications, Inc., in its Expressway filing for FCC, states that it "will provide sub-T1 to T1 (1.544 Mbps) to OC-3 (155 Mbps) and higher, to high data-rate users". [Before the Federal Communications Commission, Application of Hughes Communications, Inc. Satellite Systems. For Expressway. A Global Fixed Service Communications Satellite System. July 14, 1997, Page

3, paraphrasing]. It further states that "Each of the satellites in the system will provide the capacity equivalent of 42,000 simultaneous T1 circuits. The total global capacity of the 14 satellites Expressway system is 588,000 T1 circuits." [Page 7].

Furthermore, "The Expressway system will operate with 3.0 GHz of bandwidth in each of the two polarizations in the 50/40 GHz FSS band and 500 MHz of bandwidth in each of the two polarizations in the Ku FSS band." [Page 7.] Later, it says, "The requested V-band (50/40 GHz) spectrum will be reused 40 times over each service area. .... V-band coverage for a given area ($3^0$x$6^0$) in satellite coordinates, sufficient to cover an area the size of the 48 U. S. States) will be provided by an antenna system that offers the ability to independently select 20 receive beams and 20 transmit beams from a total of 204 narrow ($0.3^0$), dual polarized, spot beams." [Page 7.] And "The entire 3 GHz of bandwidth will be utilized in each of twenty, dual polarized antenna spot beams selected from a $3^0$x$6^0$ ubiquitous coverage area thus providing a frequency reuse factor of forty per satellite." [Page 22.]

In addition, "The 3 GHz of spectrum will be channelized into ten, 300 MHz wide frequency division multiplexed (FDM) channels, each of which are time division multiplexed (TDM) by 100 time channels or slots.... Users will be assigned a unique time slot and FDM channel and will, in general, burst data at 155.54 Mbps." [Page 24.] It also explains how they are able to provide more than 40,000 T1 circuits per satellite thus. "Since twenty dual polarized spots will be active at any given time and each beam is capable of supporting 1,000 users each at a T1 rate, the total capacity of the V-band system is 40,000 T1 circuits per satellite." [Page 24].

Expressway's satellite characteristics are summarized on page 38. [Table 4.5-1. Page 38.] Its DC power is 15kw at End-of-Life. It has 400 V-band FDM carriers, 204 V-band FDM antenna spots (dual polarization), and 20 active, dual polarization antenna spots. The station keeping accuracy is +- $0.05^0$, and antenna pointing accuracy is +- $0.03^0$. Furthermore, Expressway has a rain attenuation allowance of only 2-4 dB, to achieve an availability of only 98%. [Page 87.] This is an unusually low rain margin and low availability. The fact that fully two percent of the time a high speed user can't use the service seems utterly unattractive.

A single Expressway satellite has a footprint of roughly 12,000,000 square kilometers. [Page 7]. Each Expressway satellite has a capacity of 40,000 T1 in its V-band. [Page 24]. Now since each T1 line is equivalent to 24 (64k) channels, 40,000 T1 lines is equivalent to 960,000 channels. Also, it assume a 3000 MHz allocation each way. "The system design requires 3 GHz for uplink communications at 47.2 to 50.2 GHz (Earth-to-Space) and 3 GHz for downlink communications at 39.5 GHz to 42.5 GHz (Space-to-Earth)." [Page 22]. Hence the SUE for Expressway is 960,000/3,000/12,000,000 or $\underline{2.67\text{x}10^{-5}}$ channels/MHz/$(\text{km})^2$.

Based on the above conclusions, the relative efficiency between the conservatively designed stratospheric system and the Expressway system is $\gamma = 0.094/2.670\text{x}10^{-5} = 3{,}615$. Therefore, the stratospheric system is 3,615 times more efficient than the Expressway system under the SUE formulation.

C. The Effects of Power Limitations and the Use of High Gain Antennas on Spectral Utilization Efficiency of the Stratospheric Station and Satellite Systems.

(1) The Pritchard Power Formula

The following formula shows the relationship between power and antenna gain:

$$A_{coverage}\, B = P\, (A_{received}\, /T_{system})(1/L)(C/N)^{-1}$$

(referred to herein as "Pritchard's Formula")

Where $A_{coverage}$ is the coverage area, B is the bandwidth, P is the satellite transmitter power, $A_{received}$ is the effective receiver antenna area, $T_{system}$ the equivalent system temperature, L the system loss, and C/N the required carrier-to-noise power ratio. (W. L. Pritchard, "Satellite Communications – an overview of the problems and programs," Proc. IEEE, vol. 65, no. 3, pp. 294-307, March 1977.)

To achieve high spectrum utilization efficiency, the same spectrum should be reused as often as possible. The net data throughput D is the product of the number of times N the spectrum has been reused, the information bitrate per Hz $\xi$, and the bandwidth B: $D = N x \xi x B$. The frequency reuse factor N can be increased by using a multi-beam antenna to project multiple spot beams on the ground. Often, the bandwidth B is also reduced through channelization to reduce cochannel interference from adjacent spot beams. Hence the actual number M of spot beams required for achieving N times frequency reuse may be much higher. For example, if a 1:7 frequency reuse pattern were used, then M must be 7N.

For a fixed C /N requirement (in order to achieve low data transmission error rate) and modulation and coding scheme, the area of coverage $A_{coverage}$ is clearly affected by the available platform power P. Further, there is no reason to assume that a low altitude stratospheric system could not use the same high gain antennas used by the higher altitude satellite system. A satellite system has more stringent pointing requirement and weight restriction than a stratospheric system because of its altitude and payload limitation. Assuming the same antenna gains and the same spectrum, then $A_{received}$ should be the same since it is determined entirely by the antenna gain and the antenna efficiency and there is no reason to assume a different antenna efficiency either. Similarly, the system loss L and the system noise temperature $T_{system}$ can be taken to be the same. This leaves the coverage area $A_{coverage}$ strictly proportional to the available transmitter power P. However, for fixed transmitter antenna gain, the maximum coverage area $A_{coverage}$ is proportional to the square of the distance between the satellite/stratospheric station transmitter and the ground station. Everything else being equal, it follows that the required transmitter power is proportional to the square of the distance.

(2) M-Star Power Limitations

Since M-Star has only 1.5kw of available transmitter power, versus 20kw for the stratospheric station, and utilizes a 3 GHz+3 GHz allocation, M-Star is seriously under-powered to provide service to its entire footprint. Taking into account the square distance ratio of 4,000, the bandwidth ratio of 30, and the power ratio of 13, under Pritchard's formula, the M-Star system would actually be 1.56 million times under-powered and spectrally less efficient than a stratospheric system if both systems used the same dB gain antennas. Considering that M-Star actually has a footprint of 12,566,370 square km (which is 650 times larger than the stratospheric station's 154 kilometer diameter footprint), the M-Star system would have to employ antennas that are on average 8 times larger than those used in the stratospheric system to reduce the efficiency ratio in comparison to stratospheric stations from 1.56 million to 27,200. In fact, the M-Star system, as described in the application, is only 32,400 times less efficient than the stratospheric system because M-Star uses much higher gain antennas than those used in the hypothetical stratospheric system.

(3) Expressway Power Limitations

Since Expressway has roughly the same available DC power (15kw) as that of the stratospheric station, and utilizes a 3 GHz+3 GHz allocation, Expressway is even more seriously under-powered to provide service to its entire footprint than M-Star. Taking into account the square distance ratio of 3,000,000, the bandwidth ratio of 30, and the power ratio of 1, under Pritchard's formula, the Expressway system would actually be 90 million times under-powered and spectrally less efficient than a stratospheric system if both systems used the same dB gain antennas. Considering that Expressway actually has a footprint of 12,000,000 square km (which is 630 times larger than the stratospheric station's footprint), the Expressway system would have to